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COMPACT HEATING RADIATOR FOR VEHICLE

The invention relates to a radiator for heating the passenger compartment of a vehicle comprising at least a first fluid box extending from a first front surface to a second front surface of the radiator along a longitudinal axis contained in a median plane of the radiator, a heat exchanger bundle extending approximately along said median plane starting from the fluid box to exchange heat between a coolant circulating in the fluid box and an airflow passing through the bundle, a fluid inlet or outlet tubing projecting from the end of the fluid box located in said first front surface.

In this description, the terms "fluid box" and "tubing" refer to functional and non-structural units, with the fluid box denoting an element in which the fluid communicates directly with the bundle, and tubing denoting a pipe that connects the fluid box to components of the fluid circuit other than the radiator. As will be seen later, at least one region of the tubing may be fixed to the fluid box and may be formed by the same part or the same parts as the fluid box.

In the well-known radiator type described above, the presence of the tubing projecting from the end of the fluid box contributes to the bulk of the radiator in the direction of the longitudinal axis thereof. But the space available for the radiator in the vehicle is usually very limited,

particularly near the lower part of the radiator when it is close to the feet of the vehicle's occupants.

The presence of the tubing also makes it difficult to achieve airtightness between the front surface of the radiator and the box of the heating unit in which it is housed. This airtightness makes it necessary to insert an expensive foam gasket that is difficult to put into place and that could also be displaced as the radiator is being inserted into the box, thus weakening the sealing function. Furthermore, this function is weakened as the gasket ages over time.

The purpose of this invention is to eliminate all or some of the disadvantages mentioned above.

In particular, the aim of the invention is to provide a radiator of the type defined in the introduction, in which said tubing, starting from the first front surface, has a first part inclined from said longitudinal axis and/or eccentric from said median plane.

The inclination of said first part of the tubing makes it possible to reduce its bulk in the longitudinal direction of the fluid box, for a given length of the tubing, for example as far as an elbow. The eccentricity makes it possible for the first part of the tubing to be offset towards a first side of said median plane so as to leave an approximately planar surface on the other side of this median plane in the first front surface to achieve airtight contact between the radiator and the heating unit box, particularly with a removable cover belonging to this box, with or without insertion of a gasket.

Optional additional or replacement characteristics of the invention are described below:

- Said first part of the tubing is offset towards a first side of said median plane so as to leave a planar surface in the first front surface on the other side of the median plane, to achieve airtight contact between the radiator and a heating unit box containing the radiator.

- Said first part of the tubing is inclined with respect to said median plane.

- Said first part of the tubing is inclined towards said first side of said median plane.

- Said first part of the tubing is inclined with respect to the plane containing the longitudinal axis of the fluid box and is orthogonal to said median plane.

- Said first part of the tubing is connected by an elbow to a second part that is located on the same side as the fluid box with respect to a boundary plane perpendicular to said longitudinal axis and the tangent to said elbow.

- Said second part extends approximately perpendicular to said longitudinal axis and is also tangential to said boundary plane.

- Said second part separates from said boundary plane starting from said elbow.

- The following relations are respected:

$\cos \beta \times \sin \alpha \leq (Xmax/L)$

$\cos \beta \times \cos \alpha \leq (Ymax/L)$

$0 \leq \alpha \leq 2\pi$

$-\pi/2 \leq \beta \leq \pi/2$

where L is the length of the vector connecting the intersection points of the median axis of the first part of the tubing with the first front surface and with the median axis of the second part, α is the angle formed by said vector with said median plane, β is the angle formed by said vector with the plane containing the longitudinal axis of the fluid box and is orthogonal to said median plane, Ymax is the maximum distance available in the vehicle to house the tubing starting from the first front surface in the direction of the longitudinal axis of the fluid box and Xmax is the maximum distance available in the vehicle to house the tubing starting from the origin of said vector in the direction perpendicular to said median plane,

α and β are not both zero.

- The fluid box and at least one segment of the tubing adjacent thereto are formed by the inseparable assembly of at least two parts.

- The fluid box and said segment are formed by the assembly of two parts, each of which defines approximately half of the box and half of said segment.

- The fluid box and said segment are formed by the assembly of two parts, one of which approximately defines a longitudinal wall of the box and the other defines the rest of the box and said segment.

- The fluid box and said segment are formed by the assembly of three parts, two of which approximately define half of the box and the third defines said segment.

- Said parts are based on aluminium.

- A second fluid box extends along a longitudinal axis contained in said median plane, with the heat exchanger bundle being inserted between the two fluid boxes, one of which is associated with a fluid inlet tubing and the other with a fluid outlet tubing, and the tubing associated with the second fluid box is also as defined above.

Another purpose of the invention is to provide a heating or air conditioning unit for the passenger compartment of a vehicle comprising a radiator as defined above, wherein said box is approximately in airtight contact with an area of said first front surface which is clear due to the fact that the first part of the tubing is inclined and/or eccentric.

The characteristics and advantages of the invention are described in more detail in the following description, with reference to the attached drawings.

Figure 1 shows a perspective view of a radiator according to the invention, partially showing the box of a heating or air conditioning unit in which it is housed.

Figure 2 shows a side elevation view and Figure 3 shows a front elevation view of the radiator in Figure 1.

Figures 4 and 5 show explanatory diagrams showing how the tubing angles of inclination are calculated.

Figures 6 to 8 are diagrammatic views showing the different possibilities for assembly of fluid boxes and tubings in a radiator according to the invention.

Figures 1 to 3 show a heating radiator according to the invention for a unit for heating or air conditioning the passenger compartment of a motor vehicle. The radiator shown comprises an upper fluid box 1 that in the example extends along a horizontal longitudinal axis A1 from a first front surface F1 to a second front surface F2 of the radiator, both of which are in the vertical direction, and a lower fluid box 2 extending along a longitudinal axis A2 parallel to the axis A1, and also from surface F1 to surface F2. A heat exchanger bundle 3 is placed between the fluid boxes 1 and 2, and includes a row of tubes 4, each extending vertically and aligned in the horizontal direction between surfaces F1 and F2. The top and bottom ends of each tube 4 penetrate the fluid boxes 1 and 2 respectively to enable a coolant to circulate from one to the other through the tubes. This coolant transfers heat to an airflow passing through the bundle 3, between the tubes 4.

Two tubings 5 and 6, communicating with fluid boxes 1 and 2 respectively, project from the front surface F1, with one of these tubings being used for inlet of the coolant into the radiator and the other for discharge of the fluid from the radiator. Each of these tubings comprises a first approximately straight part 5-1, 6-1 adjacent to the corresponding fluid box, and a second approximately straight part 5-2, 6-2, connected to the first part through an elbow 5-3, 6-3.

According to the invention, the first parts 5-1, 6-1 of the tubings are inclined from the axes A1, A2, and are also eccentric from the median plane P of the radiator containing the axes A1 and A2.

The diagrammatic representation in Figure 5 gives a better understanding of these concepts of inclination and eccentricity. The end region of a fluid box 1 can be seen

in this figure, extending as far as the front surface F1 from which a tubing 5 projects comprising a first part 5-1 and a second part 5-2 connected to each other by an elbow 5-3. The longitudinal axis A3 of the part 5-1 meets the front surface F1 at a point O which, in the example, is offset laterally from the point of intersection O1 of the longitudinal axis A1 of the box 1 with the surface F1. Therefore, part of the tubing 5-1 is eccentric from the fluid box 1. Moreover, the axes A1 and A3 are not parallel, but there is an acute angle between them. Therefore, the part 5-1 is inclined from axis A1.

With reference once again to Figures 1 to 3, it can be seen that the parts of the tubings 5-1 and 6-1 are both inclined and eccentric towards the left in Figure 2, thus leaving a clear part of the width of the front surface F1 to the right of the plane P, so that a planar strip 10 can extend over the entire height of this surface, facilitating the creation of an airtight contact with the box of the heating unit as will be seen later.

Figures 1 to 3 also show that the part of the tubing 5-1 is inclined from the plane P, but is parallel to plane P1 perpendicular to it and containing the axis A1. On the other hand, the first part 6-1 of the lower tubing 6 is inclined both from plane P and from plane P2 perpendicular to plane P and containing the axis A2.

The second part 5-2 of the upper tubing 5 is oriented horizontally and is parallel to the front surface F1, while the second part 6-2 of the lower tubing 6 extends vertically. The distance D1, D2 over which each tubing extends from surface F1 depends on the length of its first part and the radius of curvature of its elbow. The inclination of the first parts of the tubings makes it possible to reduce this distance, equal to the length of the first parts and the radius of curvature of the elbows, compared with what is possible in the prior art in which these first parts are oriented along the A1 and A2 axes. Similarly, the inclination of the first

part 6-1 of the lower tubing 6 makes it possible to reduce the distance D3 by which it projects from surface F3 facing the left in Figure 2, which is one of the main surfaces of the exchanger through which the airflow passes.

Tubings 5 and 6 are entirely included between the plane of surface F1 and planes P3 and P4 respectively, perpendicular to axes A1 and A2 and located at distances D1 and D2 from this surface, with planes P3 and P4 being tangential to the elbows 5-3, 6-3 and to parts 5-2, 6-2 which in the example in Figures 1 to 3 extend parallel to the same planes. Alternatively, the parts 5-2, 6-2 are not necessarily parallel to planes P3 and P4 and can move towards the plane of the surface F1 as shown for the tubing 5 in Figure 5. In this case, the part 5-2 is no longer tangential to plane P3 but is between plane P3 and the plane of the surface F1.

Figure 4 shows a perspective view of the end region of a fluid box 1 of a radiator according to the invention, and Figure 5 shows a top view of the same region of the fluid box and the corresponding tubing 5. In Figure 5, A3 and A4 denote the longitudinal axes of the parts 5-1 and 5-2 of the tubing that intersect at point A. L is the distance along axis A3, between point A and point O at the intersection between axis A3 and the front surface F1 of the radiator. Ymax denotes the maximum allowable bulk for the tubing starting from the surface F1 in the direction Y which is the direction of axis A1. Xmax (Figure 4) denotes the maximum bulk of the tubing starting from point O in the OX direction perpendicular to the plane P. Also in Figure 4, B denotes the projection of point A on the XOY plane and α and β denote the angles BOY and AOB respectively.

The coordinates of point B in the OX, OY coordinate system are:

$L \times \cos\beta \times \sin\alpha$ and $L \times \cos\beta \times \cos\alpha$.

Therefore, the following relations should be respected to ensure that point A, and consequently point B, do not go outside the limits Xmax and Ymax:

$$\cos \beta \times \sin \alpha \leq (Xmax/L)$$

$$\cos \beta \times \cos \alpha \leq (Ymax/L)$$

$$0 \leq \alpha \leq 2\pi$$

$$-\pi/2 \leq \beta \leq \pi/2$$

where α and β are not both zero.

Any value that makes it possible to respect these relations can be adopted for the angles α and β.

Figures 6 to 8 show different assemblies each composed of a fluid box and a tubing segment fixed to the fluid box, obtained by assembling folded or stamped aluminium plate parts either by welding or brazing. This segment represents at least one initial region of the first part of the tubing, adjacent to the fluid box. These assembly types make it easy to incline and/or create the eccentricity according to the invention, and consequently the first part of the tubing formed wholly or partly from the segment.

In Figure 6, two parts 11 and 12 each define approximately half of the fluid box 1 and half of the segment 5-0 of the tubing. In Figure 7, a first part 13 approximately defines a longitudinal wall of the box 1, and the second part 14 defines the rest of the box and the segment 5-0 of the tubing. Finally, in Figure 8, each of the two parts 15 and 16 approximately defines half of the box 11, and a third part 17 approximately defines the segment 5-0 of the tubing. In each case, segment 5-0 is inclined from the joint plane of the two parts of the fluid box.

Apart from the radiator, Figure 1 shows elements 21, 22, 23, adjacent to the radiator, of the unit box which is not shown in more detail so that the radiator can be seen more clearly. In particular, the element 23 belongs to a removable cover that closes up an opening 24 through which the radiator is assembled. These elements are provided with ribs 25, 26, 27, 28 that come into contact with the radiator over its entire periphery so that it is airtight between the upstream and downstream sides of the radiator. The invention makes it easy to obtain this seal by means of the planar strip

10 (Figure 2) that provides a seating for the rib 28 fixed to the cover 23.

The invention is not limited to the embodiment described, in which the radiator has two fluid boxes extending along parallel axes each associated with two tubings starting from the same front surface of the radiator. The following alternatives in particular are possible, possibly in combination:

- a single fluid box;
- two boxes with non-parallel axes;
- a single tubing extending from a front surface of the radiator;
- two tubings, each extending from one of the two front surfaces and each associated with a different box, or both associated with the same box.